Effects of Mountaintop Coal Mining on Ground Water

Jim Eychaner

USGS

Charleston WV

Mountaintop Coal Mining

- Ground Water Issues
  - Water Quantity
  - Water Quality
- Timing of effects
  - Transient or Long-Term
  - Immediate or Delayed

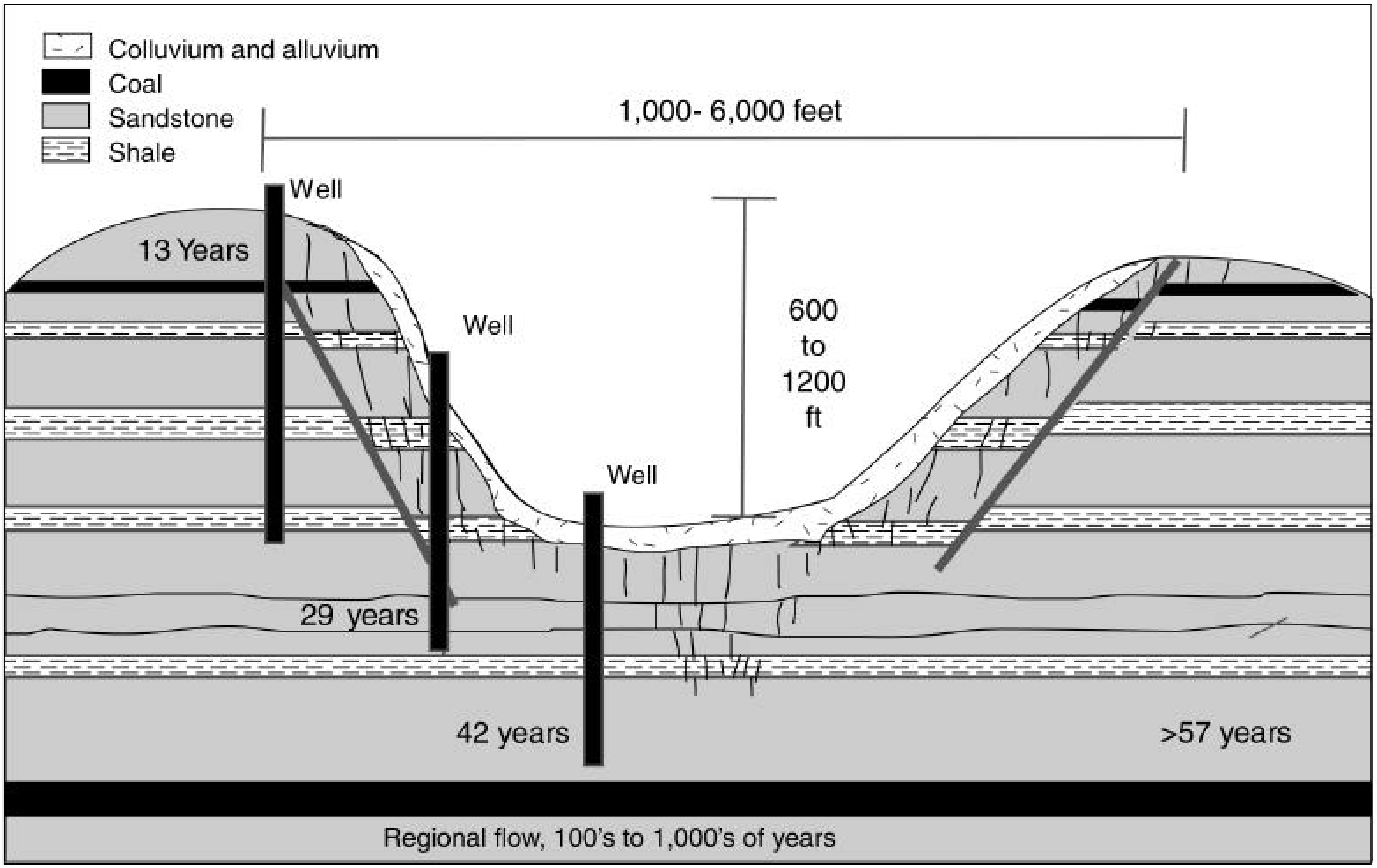
Ground Water Settings

- Fracture flow system before mining
- Granular flow system after mining
- Fracture flow system after mining
- Transition: Blasting

Before Mining

- Layered sandstone, shale, coal
  - Near horizontal
  - Well cemented (carbonate & silicate)
- Steep topography
  - Relief 600 - 1,200 ft
  - Ridge spacing 1,000 - 6,000 ft
- Dendritic drainage network

Geohydrology before mining



Fracture Network

- A blanket of fractures draped across the topography
  - Stress-relief fractures
  - High-angle joints and faults
  - Bedding-plane separations
  - Coal seams
- Permeability decreases with depth
- How do discrete fractures connect?

Ground-Water Flow

- Scale of aquifer segment
  - Ridge to valley
  - Along valley
  - Deep aquifers
- Seasonal recharge via soil, alluvium
- Apparent age of water
  - Hilltops 13 yr, Hillsides 29 yr, Valleys 42 yr
  - Effects of individual-fracture paths

Well characteristics

- 6 inch diam, 80-200 ft deep, 20-40 ft casing
- Half at base of slope close to stream
- Submersible or jet pump, 5-10 gpm
- Pump cycles every few minutes when used
- New wells have concrete pad, casing grout
- ?WL/?T < 7 ft/min or 1 ft/10 sec

Water Quality--Kanawha NAWQA

- Appalachian Plateau survey - 30 wells
  - Shallow domestic wells in good condition
  - Bacteria, major constituents, nutrients, trace elements, pesticides, volatiles, radon, CFC age
- Mining survey - 28 wells, not MTM
  - Reclaimed surface coal mines, similar wells
  - Major constituents, nutrients, trace elements, radon, CFC age

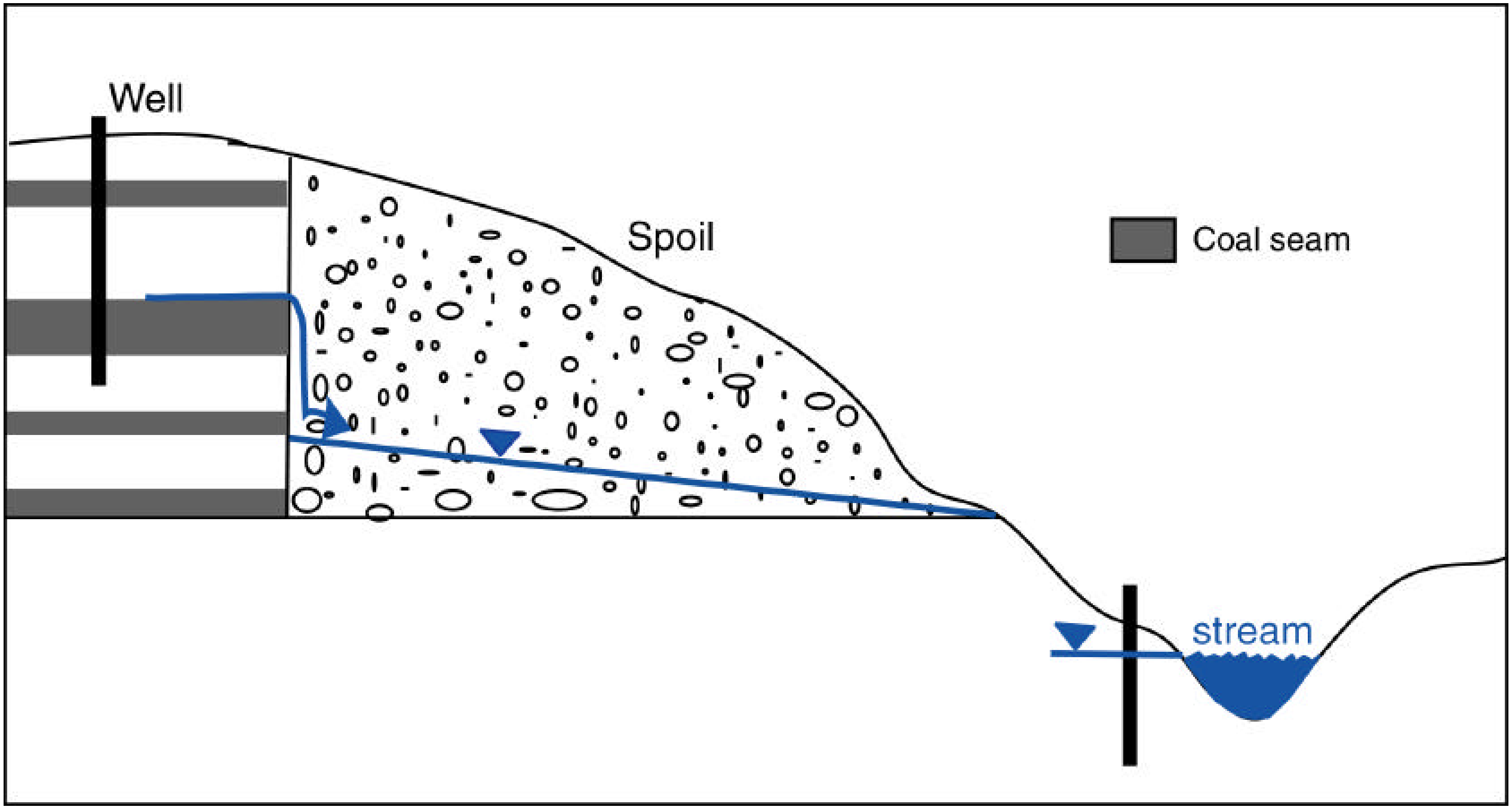
Appalachian Plateau, 30 wells

- More dilute $Ca(HCO_3)_2$ near ridges, tending to $NaHCO_3$ or Na_2SO_4 in valleys
- Fe exceeds SMCL in 40%, Mn in 57%
- Rn: median 300 pCi/L, >95% < 4000
- Total N: median 0.29 mg/L, 90% < 1.0
- Detected CS_2, $CHCl_3$, or benzene in 20-40%
- Fecal bacteria absent, Pesticides rare

Granular flow system

- In backcast or valley fills
- Permeability horizontal or angle of repose
- Coarse zones by design or chance
- Pyritic spoil high and dry in backcast

Geohydrology -- spoil on bench



Granular flow - hydraulics

- Thin saturated zone above coal pavement (backcast) or former valley (valley fill)
- Stable water table after a few years
- Recharge: increased infiltration, fractures
- Discharge: to streams, fractures
- Residence time decreased
- Permanent through-flowing system

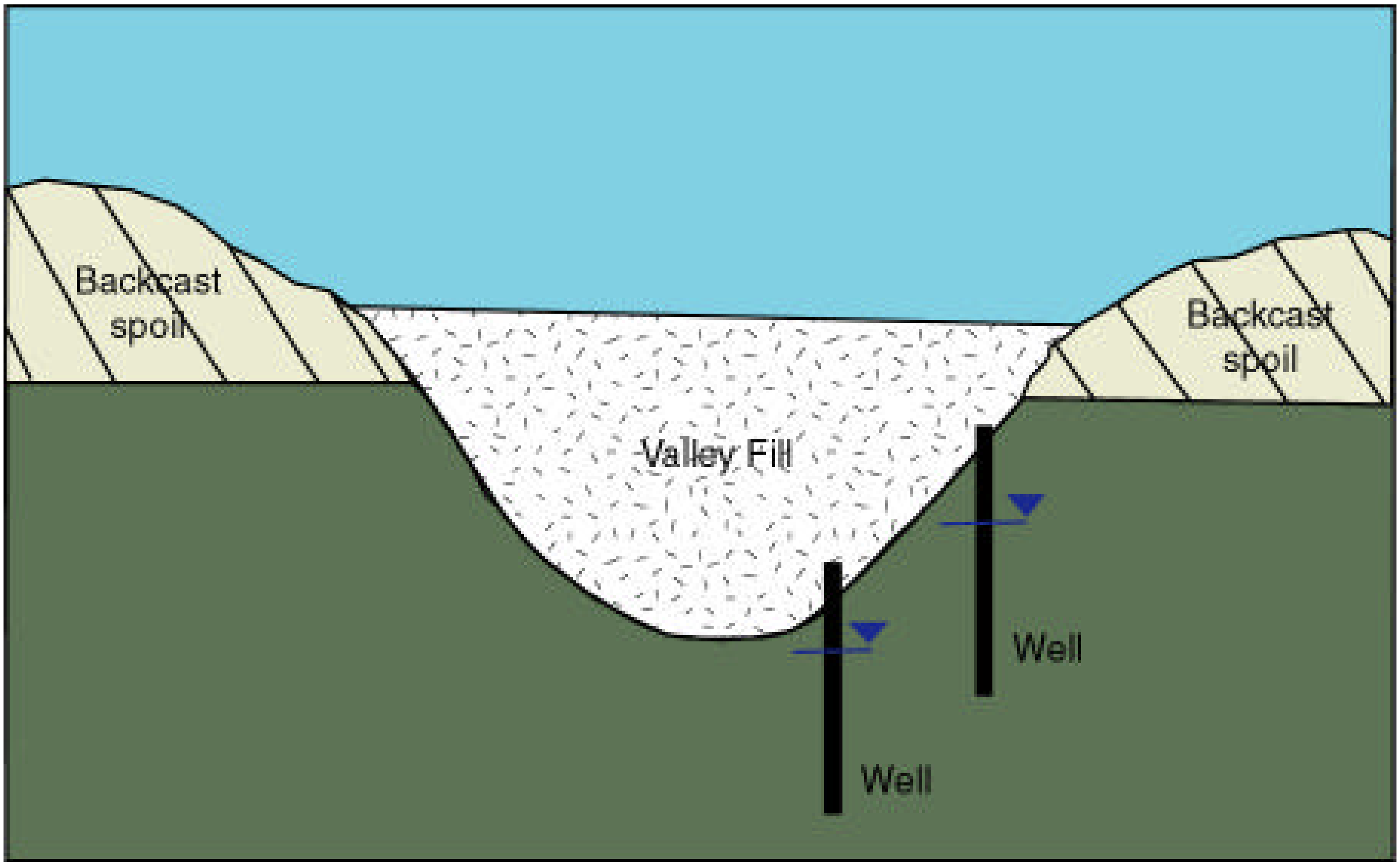
Granular flow - chemistry

- Geochemistry of new rock-water interactions -- What is on the flow path?
- TDS, SO4 increase, variable by site
- TDS gradually decreases as exposed minerals react
- Difficult to install wells

Fracture system after mining

- Fractures above highwall drain to new base
- Fractures below water table can recharge
- Progress of effects depends on
  - Specific fracture connections and flow paths
  - Residence time in each fracture
  - Geochemistry along each path

Geohydrology -- Valley Fill



Effects on existing wells

- Upslope wells can go dry
  - Water-level trend one way for days, weeks
  - Effects depend on distance
- Downslope, cross-slope well effects are more subtle
  - Multiyear lag possible

Berger & Associates (1980)

- Studied blasting effects on ground water
- Four study sites in WV, PA, OH
  - New observation wells
  - Repeated pump tests as mining approached
  - Periodic chemistry samples
- Specific capacity constant or increased

Near reclaimed mines - NAWQA

- 28 wells, complete reclamation 2-12 yr
- Effects seen within 2000 ft H, 150 ft deep
- Increased: SO_4, Fe, Mn, TDS, turbidity
- Decreased: pH, Rn
- Total N: median 0.38 mg/L, 86% < 1.0
- Apparent age unchanged, median 28 yr
- Mixed residence time on multiple paths

Blasting -- The Transition

- Effects result from vibration magnitude, frequency spectrum, and duration
- Objective: shatter rock to allow removal
  - Grid of shot holes, charged with ANFO
  - Optimize design on spacing, charge, delay
- Objective: minimize off-site effects
- Scale exceeds that of 1980

Transient effects on wells

- Water-level surge
  - Compression wave, f >1 hz, could produce surge ? A/A_0 * Height of water column
  - ?WL/?T > 1 ft/s possible
  - Surging could continue for the duration of the blast wave train
  - Compare pumping: ?WL/?T < 1 ft/10 sec
  - Effect observed in earthquakes

Transient effects (2)

- Turbidity transient possible
  - Visible water quality change immediately after blast shock felt by citizen
  - Is the science credible?
  - Most common citizen complaint in 1980 study
  - Turbidity samples in 1980 were collected only after 300 minutes of continuous pumping.

Principal Unknowns

- Pre-mining flow details
- Lag time, long-term chemistry near large fills (fracture system)
- Variability of flow in large fills of different construction
- Duration of chemical effects (granular)
- Transient water levels and turbidity